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Assessment of wood fuel use for energy generation in Lithuania

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The paper investigates possibilities to use solid biomass (wood) resources. It provides detailed analysis on distribution of Lithuanian wood resources and evaluates possibilities to develop the use of above resources for heat and power generation. European Union as well as Lithuanian legislation declares promotion measures for wood as fuel for energy generation. Legal documents suggest implementation via subsidizing of raw material for production of wood chips for boiler-houses and adopting specific promotion program for the use of forestry biomass for boiler-houses according to which the difference between price and costs should be subsidized for producers of such raw material.

Directive 2009/28/EB obligates separate countries to develop National Renewable Energy Action Plans (NREAP), which would provide specific promotion schemes and target indicators for each year (up to year 2020). According to this Directive the EU RES share in final energy consumption should reach 20%, and for Lithuanian this share should be no less than 23%, while district heating systems should use no less than 70%. At present the total capacity of wood-chip-fueled boilers reached above 476.1 MW. No series obstacles can be seen for extension of wood fuel use. The renewable energy compromise 18.1% of primary energy annual gross inland consumption and cut of the CO_2 emissions about 6% compared with the level on 1990. According to the Kyoto Protocol Lithuania must reduced green gas emissions 8% in the period 2008–2012. These goals can be realised by increasing of the use of biomass as fuel for the energy production.

Contents

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1. Introduction

Promotion of the production and use of biofuel is the priority trend in Lithuania. In 2009 gross inland consumption from biofuel reached 11.5% and solid biomass 10,8% [1]. The use of biomass is recently growing and in district heating (DH) sector. The fuel consumption for thermal centralized energy in year 2009 was 883 ktoe, and 153 ktoe in this using wood fuel [2]. Lithuanian District Heating Association and Lithuanian Biomass Energy Association raise ambitious goal that the share of heat production from RES and other indigenous fuels in fuel balance should reach 70% of total primary energy by year 2020. The installed capacity for biofuel should be approximately 2170 MW to achieve this goal. With regard to increase the share one needs to additionally construct the network of biomass CHP plants with installed capacity approximately 1560 MW, and investment should reach approximately 0.32 billion Euro. EU member states are also increasing the use of biomass to generate clean energy. Regarding ambitious EU energy targets for 2020 (20% of energy from renewable energy sources (RES) in total energy consumption), it appears realistic that biomass will make the major share of RES. According to the NREAPs biomass delivered in 2010 more than 83 Mtoe to the EU's energy consumption, with 12% electricity, 18% as transportation fuels and 70% as heat. Heating will continue being by far the most important sector for bioenergy in 2020. Taking into account that heat covers more than half of the final energy consumption in Europe, biomass should be a key sector for EU members states to meet the 2020 targets. By 2020 the biomass supply in Europe should increase to meet the demand of all sectors of heat, electricity and transport biofuels, rising from 77 Mtoe in 2006 to 122 Mtoe in 2020 [3].

Bioenergy potential in the EU from forestry is also growing. There are 178 million hectares of forests and other wooded land, about 42% of its land area. Over the past 20 years, forests have increased by 5%-approximately 0.3% per year—although the rate varies substantially between countries. The operated forests areas in 27 EU member states should stay unchanged, though politicians in some countries foresee the growth of forest area in some countries. Based on the NREAPs forest biomass potential would make approximately 60 Mtoe in 2015, and increase up to 65 Mtoe in 2020.

Extraction and use of biomass from forests cause many economic problems. Often collection of wood biomass is rather expensive because of large volumes distributed in cutting sites, while traditional wood fuel preparation systems are adjusted to processing of wood with larger measurements. Environmental impact to ecosystems from this activity is also not fully investigated.

In this paper there are represented investigations of the characteristics of Lithuania's forests and wood cutting volumes, wood fuel resources and will highlight wider use of wood cutting residues as well as promotion measures for such resource. It will also assess projections for the use of forest resources as well as fuel consumption for heat and power generation including implemented measures for promotion of this activity.

2. State policy

National Energy Strategy [4], Implementation Measures of the Programme of Lithuanian Government during 2008–2010 [5], Action Plan for National Sustainable Development Strategy [6], international obligation of Lithuanian Republic as well as other related EU and Lithuanian legislation directly regulating development of RES and various studies [7,8] make the background for legal action plan for the use of renewable energy sources (RES) and wood fuel.

Political statements promoting necessary development are necessary to use RES potential, especially for improvement of competitive ability for such energy sources. The main task for RES policy is to find respective equilibrium between possibility to implement wide range of RES capacities today and possibility of waiting till scientific research will reduce the costs of such capacities in future. It is suggested to increase RES share from current level of less than 12.9% to 20% EU energy consumption level by 2020. National Energy Strategy [4] foresees the use of modern technologies and the use of wood fuel more rationally as well as the use of economically viable potential of forest cutting residues, which should be approximately 180 thousand toe (total investment about 34.75 millionion Euro) by year 2025. Bearing in mind current prices for fossil fuel it would be feasible to use the whole potential of forest cutting residues even while mobilization of forest cutting residues is subsidized from national budget.

3. Characteristics of Lithuania's forests

The main Lithuanian legal acts regulating economic activity in forestry are as follows: Forests Law of Lithuanian Republic [9], Economic policy for Lithuania's Forestry and implementation strategy [10], Forests cutting regulations [11]. They regulate reforestation, protection and use in the forests of all types of ownership, as well as management based on uniform sustainability principles via ensuring rational use of forest resources, providing raw material for industry and improving forest productivity. Total consumption of firewood and fuel wood waste was 758 ktoe in 2009 [1]. Installed capacity of biofuel boilers is growing and wood fuel consumption makes over 85% of total RES. Lack of wood may restrict the use of wood fuel for heat and energy generation in future, thus we need detailed assessment of Lithuania's forests characteristics with regard to increase available resources.

The total forest area was 2159.8 thousand ha on January 1, 2010 and it covered 33.1% of Lithuania's area [12]. This area increased by 130.0 thousand ha since January 1, 2001 and total forest coverageby 2.0%. Coniferous trees are prevailing tree species (56.3%); soft deciduous trees make 39.6%, and hard deciduous trees −4.1% of total forests. Total growing stock volume, mill. m^3 (NFI) was 479.4 millionion m^3 on January 1, 2010.

Lithuania's forests are to be increased according to National Sustainable Development Strategy [6] and Forests Coverage Increase Program [13] by 2–5% till year 2020. Forests of State ownership made nearly half (49.4%)–1068.0 thousand ha-of total forests area on January 1, 2010. Forests reserved for restitution made 12.2% (262.7 thousand ha). Private forests, which made 829.4 thousand ha (38.4%), were managed by 242 thousand forest owners. Most private forests are protective forests. Thus private forests play important environmental role and the use of wood is more complicated in such forests.

3.1. Forests cutting

Based on data of State Forest Management Service [12] 5.7 million m^3 of wood was cut in all forests of Lithuania in 2009. It decreased by 0.1 million compared with 2008. Removals from state forests were stable over 2006–2008 years. Increase by 0.1 million was reached in 2009. Removals from state forests totaled 3.6 million m^3 of round wood. From this, 3.3 millions where felled by enterprises themselves or by contractors, while stumpage sales made up 0.3 million m^3.

Main cuttings reached 2.6 million m^3/a in state forests. Intermediate cuttings made about 1.1 million m^3/a of wood. Cuttings from sanitary cleanings increased. The volume of sanitary cuttings reached 612 thousand m^3 which is related to declining of forests quality. Current cuttings made 321 thousand m^3. Thinning increased up to 82 thousand m^3. Total amount of 2.0 million m^3 of wood is annually cut in private forests. State Forests Management Service provides data on wood volumes, which have permissions for cutting in private forests. However, certain share of wood

Table 1
Wood resources.

Forests	Volume of liquidation wood thos. (m^3)							
	Logs		Pulpwood		Firewood		Total	
	2010	2025	2010	2025	2010	2025	2010	*2025*
Total	3848	4649	1332	1609	*2220*	*2682*	7400	8940

Table 2
The volumes of cutting residues from main and intermediate cutting areas.

	Main cuttings, Thos. m^3			Intermediate cuttings, Thos. m^3		
	Branches	Stumps	Total	Branches	Stumps	Total
Coniferous	370.3	612.4	982.7	217.6	377.9	595.5
Deciduous	378.9	562.1	940.9	101.3	139.5	240.7
Total	749.2	1174.5	1923.6	318.9	517.4	836.2

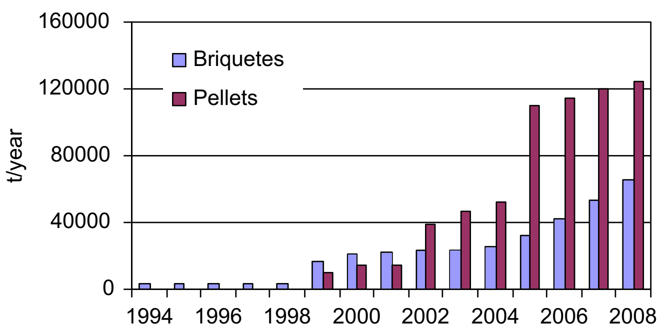


Fig. 1. Production of pressed briquettes and pellets in Lithuania.

(alder, aspen) does not need permission for cutting in private forests. This share cannot be found in statistics, which makes statistical data not accurate.

3.2. Wood fuel resources

There are three main wood fuel resources: firewood from main and cultivation cuttings, residues from wood processing industry and forest cutting residues.

3.2.1. Firewood

Firewood is part of the stem which cannot be processed. According to the data of Directorate General of State Forests 0.606 million m^3 of firewood was sold in year 2006. In year 2007 firewood sales reduced to 0.443 million m^3, and this amount increased to 0.503 and 0.623 million m^3 in years 2008 and 2009, respectively.

Data in scientific report [14] states that rural population consumes approximately 1.80 million m^3 of wood fuel in Lithuania. Most of it is firewood – 1.47 million m^3 (81.36%). The rest is other types of wood fuel, i.e., non-forest trees, cutting residues, sawdust and cut-offs from sawmills as well as wood briquettes. 35.51 % of rural population produce fuel in areas which belong to their families, 17.16 % buys wood fuel from state forest enterprises, and the rest share usually purchase from private companies, physical persons, etc. in Lithuania.

Projections of Directorate General of State Forests and Ministry of Environment shows that firewood resources for year 2010 were evaluated with assumption that logs, pulpwood and firewood will be distributed as shown in Table 1.

Statistic data does not include the share of firewood from private and state forests, which is produced and consumed by population on their own. With assumption that such wood makes approximately 20%, the volumes of firewood would be 2664 thousand m^3 and 3218 thousand m^3 in years 2010 and 2025, respectively.

3.2.2. Wood processing residues from industry

Wood processing residues from industry is the share of wood which does not get into the product after mechanical processing. There is not much statistics on the volumes of wood residues in industry. Average waste volume is approximately 1.58 million m^3 (41%). This percent of residues was formed in the saw-mills and was used for assessing the volumes of waste in wood processing industry in 2010. Most residues which are later used for fuel are formed in small sawmills with obsolete installations and technologies. About 10 saw-mills with high capacity working mainly for export and about 40–50 saw-mills cutting wood for internal market would be the most optimal option for Lithuania. It is expected that the volumes of wood residues after processing of industrial wood will reduce to 35% in 2025. Part of residues from wood processing industry is used for production of pressed fuel-briquettes and pellets (Fig. 1)—in Lithuania; production volumes of such fuel is approximately 170 thousand tons per year. Unfortunately, major share of about 85% of such fuel is exported.

3.2.3. Forest cutting residues

Forest cutting residues are the least used wood fuel resources up till present. Cutting residues are the tops of felled trees, not used branches (with diameter < 5 cm), small-diameter tree stems (diameter ≤ 5 cm at the height of 1.3 m) and stumps. Wood processing industry uses wood of the highest quality and heat producers use residues after processing and forest cutting waste. The need for construction wood reduced significantly during economic recession, some saw-mills suspended their activity and closed, this led to significant reduction of saw-mills waste, thus there is need to use forest cutting residues fully. The assessment of the national forest service [15] states that annual production of cutting residues is about 2.5 million m^3. The potential of cutting residues in state forests was evaluated in [16], and estimated in private forests using State Forests survey performed on Jan. 1, 2008 as well as regulations, used in Lithuania's data in Global Forest Resources Assessment [17].

The main share of high quality wood, as well as large volumes of forest cutting residues is formed during main cuttings in mature forests. Recently with the change of manual cutting to machinery the volumes of cutting residues increased. The large volumes of cutting residues form in coniferous forests which are prevailing in Lithuania. Total volume of cutting residues in coniferous forests reaches nearly 983 thousand m^3 in which 370 thousand m^3 are wood from branches and stem residues and 612 thousand m^3 are wood from stumps. Data on state forests shows that nearly 572 thousand m^3 of wood comes as waste from forests managed by state forestry enterprises, including 242 thousand m^3 of wood from pines and 330 thousand m^3 of wood from spruce. Nearly 379 thousand m^3 per year of branches and stems residues will come from main felling in deciduous forests during years 2009–2013 and 562 thousand m^3 more will come from stumps. The results of planned cutting residues [18] are presented in Table 2.

Wood from intermediate felling in all Lithuania's coniferous forests gives 596 thousand m^3. This total volume includes 218 thousand m^3 of branches and stems residues and 378 thousand m^3 of stumps residues (127 thousand m^3 from branches and stems, and 220 thousand m^3 from stumps in state forests annually). It is expected that deciduous forests will provide 101 thousand m^3 of wood from branches and stems and 140 thousand m^3 of wood from stumps.

Generalized data shows that total volume of cutting residues should reach 2.759 million m^3 of wood during years 2008–2013

in which 1.068 million m^3 of wood will come from branches and cutting resides and 1.692 million m^3 will come from stumps.

With regard to use forest cutting residues from main and intermediate felling for fuel as much as possible one needs to evaluate the following bearing in mind raising environmental crisis:

- Environmental risks related to degrading and mechanical damage of soil via extracting part or all cutting residues;
- Occurring mechanical damage for the remainder plants via applying various technologies;
- Fire risks;
- Environmental risks related to pervasion of bugs and damage risks from extraction and storage of forests cutting residues (including stumps);
- Possibility to use stumps, including the impact to forest soil and ecosystems from tearing activity.

Having evaluated risks factors [18] it was defined that while cutting annually 6.12 million m^3 of wood assigned for liquidation during years 2009–2013 in Lithuania's forests including 4.12 million m^3 via main felling and 1.90 million m^3 via intermediate felling, will provide 2.12 million m^3 of forest cutting residues annually, in this 1.068 million m^3 of wood from branches and stems and 1.12 million m^3 of wood from stumps. Maximally available amounts in these volumes will be 613 thousand m^3 from branches and stems and 373 thousand m^3 from stumps.

Algorithm for estimating forest cutting residues was elaborated and theoretical volumes of potential forests cutting residues were estimated in every state forestry enterprise [19]. Data on wood volumes from main and intermediate cuttings, on volumes of cutting residues and non-liquidated branches in year 2006 and in every state forestry enterprise served as a background for estimations. It was defined that the volume of potential forest cutting residues was 1084 thousand m^3 in state forests or 1.27 times more that data provided by state forestry enterprises in year 2006 (850.4 thousand m^3). The difference is because of not sufficient accuracy of data and mathematical models, used for assessment of biomass resources for various tree species. All Lithuania's forests have accumulated approximately 1.7–2.2 million m^3 of potential forest cutting residues and volumes will depend on felling volumes. It is projected that these volumes will increase: 6.3 million m^3/a during years 2001–2010, 7.5 million m^3/a during 2011–2020 and 8.3 million m^3/a during 2021–2030, thus the volumes of cutting residues will grow also, however these volumes can also reduce because of changing growing conditions and technological processes. The use of forest cutting residues for wood fuel in some locations is restricted by the fact that it is impossible to remove waste, and in some other more damp locations residues are used for enforcement of haul. There is no accurate data about the volumes of forest residues that are required for enforcement of hauls so one should use similar research and recommendations.

According to the data of Directorate General of State Forests [20] state forest enterprises were increasing the sales of forest cutting residues in Lithuania (Table 3). One of the main reasons why the rest cutting residues are not used is that production costs are higher that the price for such products.

There are several more wood resources, which could be used as fuel, i.e., bark. Nobody removes bark during cutting from logs in the forests in Lithuania, and total volume of bark makes 8–14% of bark volume, for this reason the extraction volume of cutting residues is reduced significantly. Assessment of bark volumes show that all annual amount of bark could reach 890 thousand m^3/a, of which 465 thousand m^3 per year could be used. Similar situation exists for stumps, as on-ground part is assigned to potential wood cutting residues, however in reality nobody extracts stumps in the forests in Lithuania. Swedish experience shows that this is feasible in damp, peaty soils, where spruce stumps can be used as biofuel; however, there is not so much spruce in mentioned soils in Lithuania.

Alder is another not used potential of biofuel. Growing conditions for alder are close to perfect in Lithuania, they not only grow fast, mature rather early, give abundant and frequent production, but also reforest by themselves. Alder area is nearly 130 thousand ha (6.4% of total forest areas) [21]. The volume of alder wood reaches 17 million m^3 (4.3% of total trees volume). The potential volumes of alder resources which could be used for fuel (including cutting residues) would be nearly 8 million m^3, in which approximately 5.6 million m^3 are is reserve forests, 2 million m^3 – in private forests and about 0.3 million m^3 – in state forests. 0.4–0.5 million m^3/a (80 ktoe) of wood can be prepared every year.

4. Promotion of production for forest cutting residues

As we can see from the data provided in Table 3, that sales of forest cutting residues are growing slowly. One of the main reasons is that production costs are higher that the price of such product. With regard to promote production of wood fuel, foreign countries apply various support schemes: environmental fees for other types of fuel, subsidizing, development of new technologies. As experience of some countries shows, biofuel production is subsidized. For example, Finland subsidizes up to 8 EUR for each cubic meter of biomass used for biofuel production with the aim to use available biomass resources owned by forest owners more rationally. Finnish subsidy divides into two parts. First part is used for extraction and transportation till the place convenient for biofuel production. Another part is given for biofuel produced from residual biomass. Support for providing residual biomass for biofuel production should be 3.40 Euro/m^3, and support for biofuel production from residual biomass should be 4.60 Euro/m^3.

With regard to use residual biomass (forest cutting residues, thinning and cleaning residues as well as other residual biomass resources) targeted economic promotion and implementation schemes are needed. Such promotion will be based on principles of simplicity, efficiency, rationality, transparency and stability of supply. Implementation of promotion schemes requires definition of the status of support receiver. This could be the owner of biomass, producer of biofuel or bioenergy. Performed analysis [22] shows that support to biofuel producers is most reasonable as the object and the sense of support appears when biofuel is produced

Table 3
Sales of wood cutting residues in Lithuania.

Year	Thos. (m^3)
2004	22.1
2005	64.5
2006	75.6
2007	54.7
2008	71.6
2009	101.1
2010	75.0

Table 4
Volumes of wood assigned for cutting in Lithuania's forests.

Year	2011–2020	2021–2030
Cuttings	Million. m^3 of liquidation wood per year	
Protected and exploitable forests		
Protected and exploitable groups of forests	7.51	8.34
Special purpose forests		
Total cuttings	0.45	0.60
Total	7.96	8.94

using residual biomass and becomes commodity, in other cases it is just waste. The costs for production of wood raw material using wood-chips were estimated and compared to market prices of such material. It was defined that costs of raw material for production of wood chips exceed the prices: for wood cutting residues –2.6–6.1 Euro/m^3, from cultivation of young forests –2.3–11.8 Euro/m^3, from cutting of not mature alder forests –2.9–5.5 Euro/m^3.

5. Use of wood fuel

5.1. Projections on the use of forest resources

On the basis of [11] nearly all cut wood will be received from 1862 thousand ha area of protected and exploitable forests, and 261.97 thousand ha area of special purpose forests. In prospective cutting volumes in special purpose volumes can grow to 0.5–0.6 million m^3 per year in 2030 after increase of mature trees area. Using mathematical simulation projections of forest resources change and use was performed [23]. Achieved results show that largest share of wood would be prepared in main cuttings by year 2030. 4.8–5.3 m^3/ha of liquidation wood or 5.5–6.1 m^3/ha of stems volume is planned from protected and exploitable forests of state ownership during closest two decades. The main outcome of projections is presented in Table 4. 3.1–4.7 m^3/ha of liquidation wood and 3.5–5.4 m^3/ha of stems volume would be cut in private and other forests. Later investigations [20] show that wood production would be approximately 7.1 million m^3 in 2010 and assortment would distribute among: logs –3.7 mill. m^3, pulpwood –1.3 mill. m^3 and firewood –2.1 mill.m^3.

About 1.3 mill. m^3 of timber per year is not delivered only from the forest reserved for the restoration of the ownership rights (which comprises 262.7 thousand ha or 12,2% of the forest area). Lithuanian industry suffers a loss of potential timber because no activity in performed in the areas until property is returned to the owners.

The aspirations of Lithuanian District Heating Association and Lithuanian Biomass Energy Association are that the share of renewable and other indigenous energy resources in heat production fuel balance would be not less than 70% in all primary energy till year 2020, thus the following measures should be implemented:

- Use of all feasible potential of forest cutting residues.
- Establishing and implementation of logistics systems for biofuel collecting and use.
- Revision of the Law of LR on biofuel, biofuels for transport and bio-oils (News., 2004, Nr. 28–870), with respective defining the use of forestry production as raw material for biofuel.
- Implementing of economic promotion. The Government should adopt specific program for promotion of the use of forestry biomass for fuel. Promotion schemes should be applied to raw material producers and forest owners. The promotion size should be differentiated by the type of resource. Promoted wood volumes should be increased gradually, e.g., from 100 thousand m^3 in 2010 up to 600 thousand m^3 in 2020.
- Financing research on the use of wood fuel, environmental consequences and possibilities for mitigation of these consequences.
- Revision of the structure of forest cutting residues and to establishing accounting system for stumps wood resources.
- Establishing of resources assessment methods for wood from non-forests areas together with inventory system (scientific research); to perform the assessment of such wood resources and feasibility study for its use.

Wood incineration is related to several positive aspects: environmental, as emissions of pollutants are reduced, loading of landfills are also reducing, social, as production and use infrastructure is established for wood fuel preparing via collection transportation and use of forest cutting residues, and economic, as less fuel should be imported, more means are left for development of economy and industry. Reconstruction of boilers, adjusting them to wood fuel (wood chips and sawdust) started with

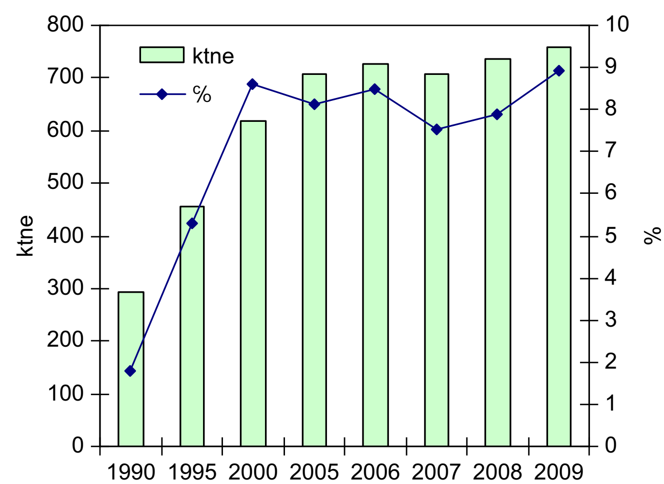


Fig. 3. Wood fuel consumption (wood fuel share in percent in primary energy balance).

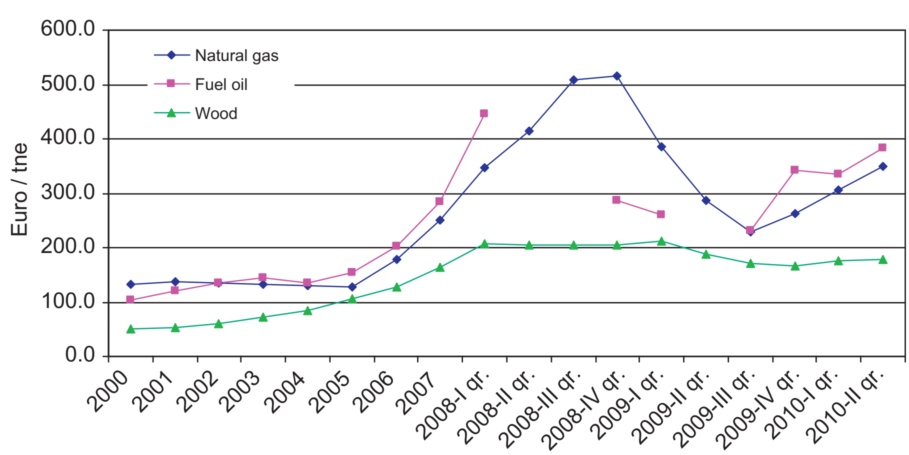


Fig. 2. Fuel prices dynamics during 2000–2010 year.

Table 5
Structure of wood fuel consumption during 2001–2009, in percent.

Areas of wood fuel consumption	2001	2005	2009
	%		
Boiler-houses and power plants	10.5	20.6	32.7
Industry	6.6	13.3	8.3
Construction	0.4	0.6	0.4
Agriculture	1.4	0.9	1.2
Tertiary sector	6.1	4.3	3.8
Households	74.9	60.4	53.6

Table 6
Comparison of fuel structure in district heating system.

Type of fuel	1996	2000	2001	2002	2003	2004	2005	2006	2007	2009
Natural gas	59.1	80.3	74.8	75.5	81.3	80.5	82.1	79.9	77.3	73.7
Heavy oil fuel	37.9	16.4	21.1	18.5	9.9	6.9	5.0	5.4	4.7	5.4
RES	0.3	1.2	1.5	3.8	7.3	10.9	11.2	13.0	16.2	19.3
Other fuel	2.7	2.1	2.7	2.2	1.5	1.7	1.7	1.7	1.9	1.7

technical and financial support of Scandinavian countries. Investment for installation of new wood chips automatic boiler of average capacity (5–10 MW) reach 0.174 million Euro per MW. Average costs for reconstruction of heavy oil fuel or natural gas boiler and adjusting it to burning wood chips costs are 0.1 million Euro per MW. Payback period for reconstructed ones is 5.4 years and 6.8 years for new ones. Energy generation costs are 36.02 Euro/MW h in reconstructed plants, and 29.60 Euro/MW h in new ones in average.

Fast growth of wood fuel boilers was defined by wood fuel price which was 2 times lower than that of heavy oil fuel and natural gas (Fig. 2) [24], and such situation existed till the 3rd quarter of year 2008. Wood fuel price was not changing for nearly one year and stayed constant (about 203 Euro/toe). Prices for heavy oil fuel and natural gas reduced notably during economic recession period. The future development of these three types of fuel will depend on development of global economics.

Wood fuel consumption grew more than two times during 1990 – 2009—from 284.9 ktoe to 758 ktoe, and this made 2.6% and 8.9% of gross inland consumption, respectively (Fig. 3). The analysis of wood fuel consumption structure shows that the largest demand is in household sector (Table 5). This demand reduced for about 20 % (90 ktoe) since 2001. Burning of wood in boiler-houses and power plants increased significantly (about 18%). Constant growth of the number of wood fuel boilers of larger capacity led to the situation that lack of wood fuel became restricting factor for further development of bioenergy.

5.2. Use of wood in district heating (DH) systems and power generation

Recently while implementing the statement of Lithuanian National Energy Strategy and EU Directives the National strategy of further development in heat sector in Lithuania should be revised. It should raise and implement new tasks. Lithuania uses renewable energy sources for heating and the largest share of 85% belongs to wood fuel. The main biomass resources used for heating are wood and wood waste. 17.4% of district heating was produced using wood and wood waste in year 2008.

Fossil fuel dominates in Lithuanian district heating sector. Most of it was natural gas and heavy oil fuel till year 2003 [24]. And since year 2004 wood and sawdust found strong second place in fuel balance (Table 6). To reach the goal of 70% RES use in fuel

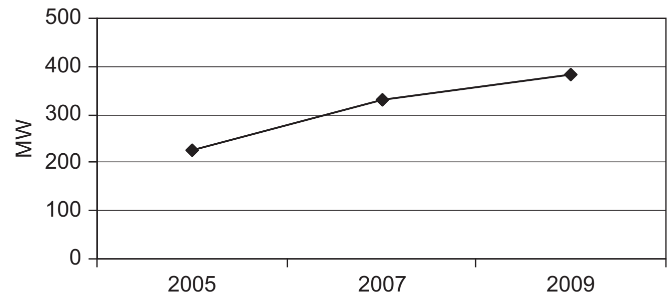


Fig. 4. Dynamics of installed biomass capacities in Lithuanian DH sector.

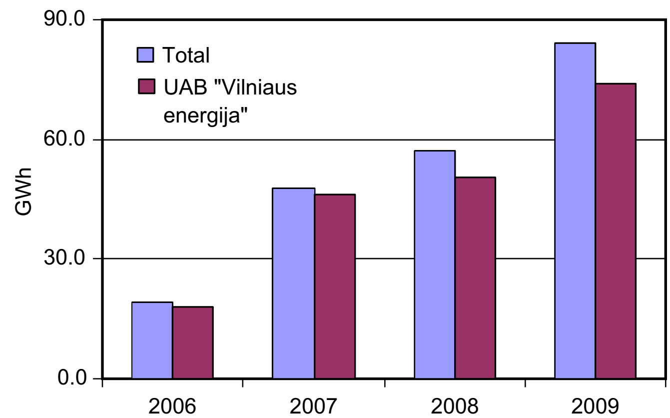


Fig. 5. Power generation in wood fuel power plants.

balance for heat production one needs 4.5% annual growth in the use of biofuel. The total capacity of heat generation installations in district heating sector reached 385 MW (Fig. 4) in 2009 [25]. To reach the 70% energy share from biofuel additional 1 GW capacity of biofuel installations are required. One needs to use unused potential of energy resources or implementation of above goals. Currently this unused potential consists of 700 ktoe of wood, about 370 ktoe of straw and 85 ktoe of other agriculture waste, 200 ktoe of municipal waste, 27 ktoe of biogas and 19 ktoe of geothermal energy.

The importance of indigenous energy resources recently is becoming more important, energy technologies on the use of biofuel and other indigenous sources are fast developing. Technological chain of the production and use of biofuel and other indigenous energy resources includes wide range of measures, starting with scientific research for rational use of resources and environment protection to technological and technical solutions for mastering and efficient use of these resources. While analyzing foreign and available Lithuania's experience one may state that regardless to more complicated (and more expensive) technologies, related to the use of biofuel and other indigenous resources, problems arising can be solved successfully and in practice there are no technological barriers for reaching set targets.

There are four wood fuel burning power plants in Lithuania. The largest power plant is in Vilnius and belongs to JSC.Vilniaus energija" with installed capacity 12 MW, another one is the boiler-house in Marijampole region (capacity 2.5 MW). The third is JSC "Plungės bioenergija" (capacity 2 MW) and the forth is JSC "Pramonės energija" (capacity 1.5 MW). Power plants were constantly increasing power generation since 2006 (Fig. 5). The share of electricity generated using renewable energy sources made 4.9% in total power consumption in 2009. In this 56% of power was generated by hydro power plants, 21% by wind power plants and 11% by biofuel plants and by biomass.

5.3. Measures implemented for promotion of power generation using RES

5.3.1. Increased power purchasing tariff

It obligates to purchase electricity produced using RES, applied since year 2002 and will stay unchanged till December 2020. Since January 1, 2009 increased power purchasing tariff, produced using biomass fuel in power plants is 0.087 Euro/kW h.

5.3.2. Investment subsidy

It is provided by Lithuanian Environmental Investment Fund, which compensates 40% of connection costs to power grid operator which ensures connection to power grid for electricity generator using RES.

5.3.3. Fees allowances:

According to Lithuania's legislation excise duty is not applied for electricity from RES. According to Heat law municipalities are forced to purchase heat, which is supplied to heat network and produced using RES.



Fig. 6. Installed capacities of the biomass burning boilers for energy productions in different Districts of Lithuania.

6. Environmental and social impacts of expended use of biomass in Lithuanian

Policy related to renewable energy was included into the updated National Energy Strategy that was approved by Seimas of the Republic of Lithuania on 18 January 2007. In 1992 Lithuania together with 154 other countries has signed the United Nations (UN) Framework Convention on Climate Change FCCC in Rio de Janeiro and other documents compliant with EU environment policy. Lithuanian Parliament ratified the Convention in 1995 and the Lithuanian Government approved FCCC National Programme in 1996. Its major goals are reduce the climate change impact and cut the CO_2 emissions as well as address other environmental issues. According to the Kyoto Protocol, which was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005, Lithuania must reduced from 2008 to 2012 green gas emissions 8% compared with level on 1990. To achieve this goal must be reduced the import of fossil fuel resources.

In Lithuania the primary energy annual gross inland consumption during years 2001 to 2010 varied from 8.2 to 8.7 Mtoe. In this period the share of gross inland consumption of renewable energy sources increased approximately from 8.3% to 18.1%. In 2010 the gross inland consumption of imported fossil fuel comprises 81.7% and local fuel −18.3%. There were used the imported fossil fuels as well as a crude oil and petroleum products (36.2%), a natural gas (35.4%), electricity (7.3%) and coal and coke (2.8%). The local fuel as well as renewable energy sources compromises 18.1% and peat and other compromises 0.2%. The share of wood fuel compromises about 88% all renewable energy resources used in the country. The biomass burning boilers have been installed in all Districts of Lithuania (Fig. 6).

The cut of the CO_2 emissions could be achieved approximately 6.49% compared with the level on 1990 when we change the crude oil by biomass and 4.74% when we change the natural gas by biomass. It is evident that Lithuania can achieve the requirements of the Kyoto Protocol only by increasing the use biomass as a fuel. The distribution of the forests in Lithuania are enough acceptable for biomass use as fuel (Fig. 7).

In Lithuania there was developed a strong institutional basis for climate policy. The government obligates the ministries, departments, state services, companies, offices and organizations to comply with the requirements of National Energy Efficiency Programme (NEEP) in energy consumption area as well as in drafting the forecasts for development and restructuring of industrial branches. The ministers, directors of departments and chiefs of other state services are directly responsible for the implementation of National Energy Efficiency Programme in the area of their authorization. All institutional structure is closely connected one with other. In the last 10 years the enhanced use

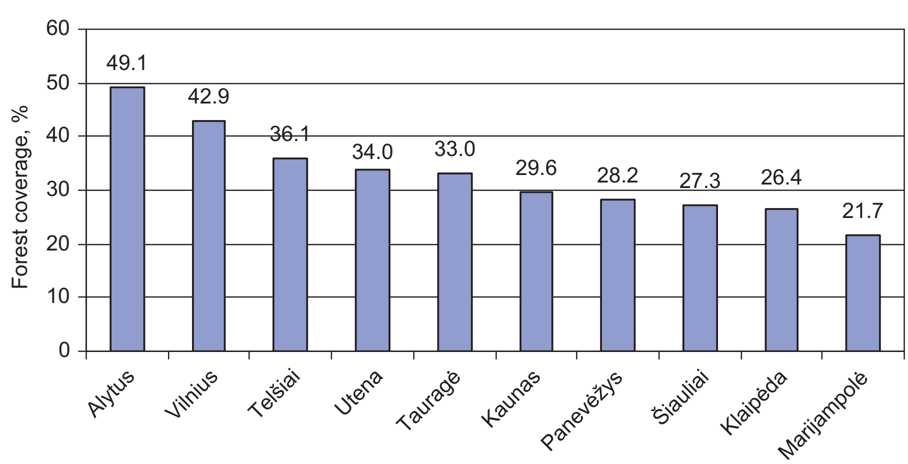


Fig. 7. Share of forest coverage in different Districts of Lithuania.

and acceptance of renewable energy projects in Lithuania has based on strong NGOs movement. This keep the debate alive and disseminate information about possibility use of RE in Lithuania and information about new technologies which were used in others countries. In Lithuania there are such main NGO as well as Lithuanian Green movement, Fund of information on renewable energy "Green Farmstead" and other ones.

Currently, Lithuania has not sufficient local energy resources and must intensify the use renewable energy sources. To practically and economically achieve energy independence in the long term, Lithuania should strive to maximize the use biomass fuel. Total energy independence could be achieved when all its electrical, heating and transportation needs are satisfied by internally supplied resources.

7. Conclusions

Wood fuel makes the largest share of renewable energy sources in Lithuania. After full mastering of these resources – firewood and industrial waste as well as forest cutting residues – it would provide 847 and 169 toe (43.5% and 8.7%), respectively in RES balance in 2020. Legislation of European Union as well as that in Lithuania declares necessity to promote the use of renewable energy sources including wood biomass. We suggest implementation via subsidizing of raw material for production of wood chips for boiler-houses and adopting specific promotion program for the use of forestry biomass for boiler-houses fuel according to which the difference between price and costs should be subsidized for producers of such raw material.

The largest areas and volumes of alder are in the forests reserved for restitution (approximately 67%) and in private forests (approximately 23%). Alder resources from forests assigned for restitution are currently not used. Their use in future will be defined by the speed of land reform and property form. 0.7–0.8 million m^3 of wood cutting residues (branches) could be collected and used in private forests only as well as alder with area nearly 130 thousand ha (6.4% of total forests area), wood volumes—17 million m^3 (4.3%).

Development of solid biomass fuel extraction and use requires scientific research and experimental development in the areas of energy biomass cultivation, fuel processing and use, creating and improvement of technologies, investigating of biofuel quality factors and certification in terms of renewability and environment protection.

Development of biofuel production and use is directly related to the problems of collecting, storage and transportation of cutting residues. For this purpose one should elaborate promotion schemes for collecting, storage and transportation infrastructure of cutting residues. Funding of such schemes must be foreseen in annual budgets of Lithuanian Republic and municipalities.

The most efforts in Lithuania were aimed at developing biomass (wood, chips, wood waste) and other renewables projects and their subsequent implementation. At present the total capacity of installed wood-chip-fueled boilers for energy production sector reached above 476.1 MW. The goal is reach the share 70% of the thermal energy by biomass. No serious obstacles can be seen for extension of wood fuel usage. Prices of fuel market depend on local conditions as well as of the number fuel consumers, capacity of installed of the wood burning boilers, etc.

In this time the renewable energy sources compromise 18.1% of primary energy annual gross inland consumption and cut of the CO_2 emissions about 6% compared with the level on 1990. According to the Kyoto Protocol Lithuania must reduced green gas emissions 8% in the period 2008–2012. It is evident that biomass fuel will help to reach this goal.

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